FIG. 1

602

603

2

2

601

FIG. 2A

604

609

FIG. 2B

605

FIG. 2C

606

609

608

607

FIG. 3

PLATES STACKED FOR RULING

FIG. 3A

PLATE 10

DOWEL HOLE R

$k1+n(d+s)$

DOWEL HOLE M

$k2+d$ even

DOWEL HOLE R

DOWEL HOLE M

FIG. 4

RULED GROOVES 14 20 L

12

10

21

GROOVE DEPTH "d"

FIG. 5

SIDE OF PLATE FORMS ONE FACE OF CUBE

a

12

10

17 19 18

6

6

PLATES ARE OFFSET BY THE GROOVE DEPTH VERTICALLY AND HALF THE GROOVE WIDTH HORIZONTALLY

FIG. 6A

10 10

19

18

17

FIG. 6

6A

6A

6B

t

$d=0.707t$

x

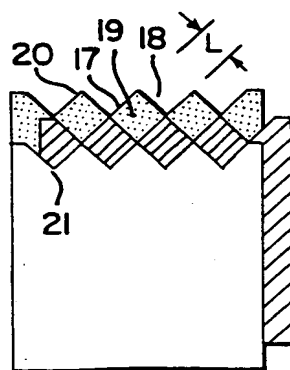PLANE OF CUBE APICES

6B

$L=t$

FIG. 6B

20 17 19 18 L

21
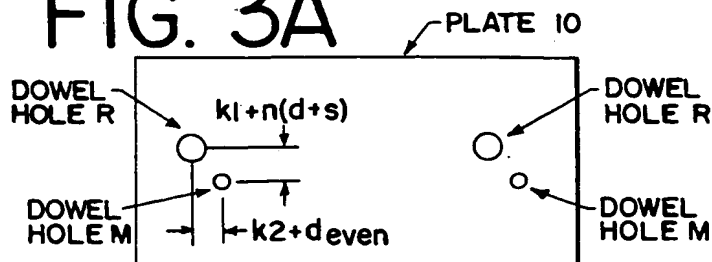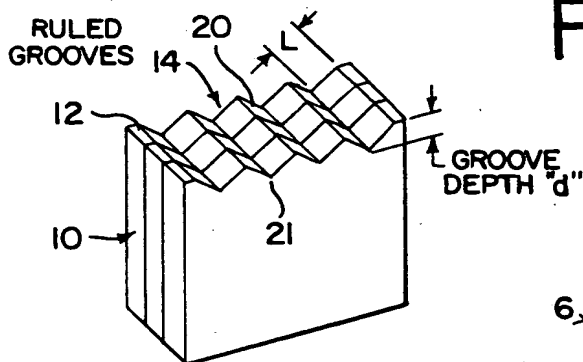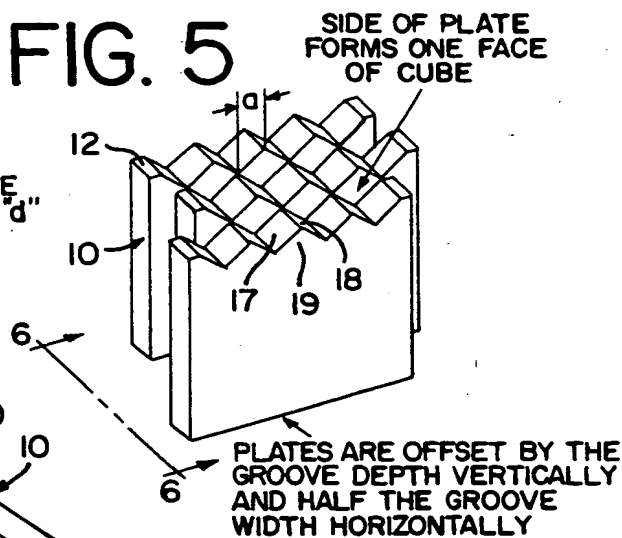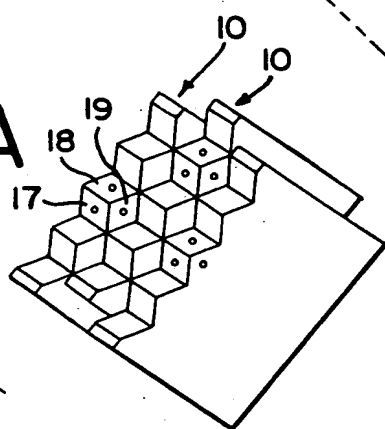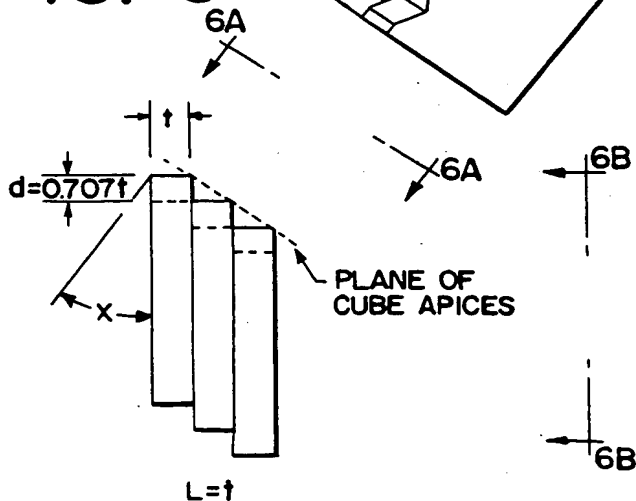
6B

FIG. 7A
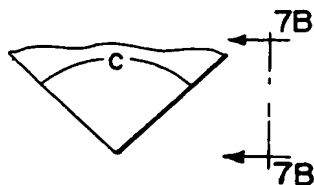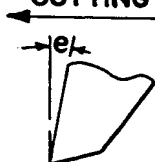
FIG. 7B

FIG. 9
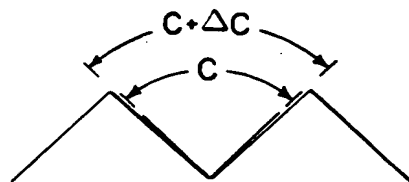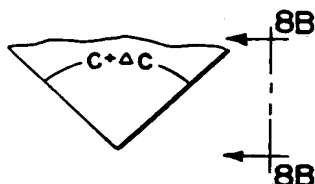
FIG. 8B

TOOL DIRECTION DURING
CUTTING

FIG. 8A
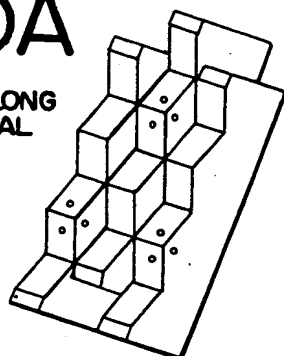
FIG. IOB

PROJECTION PERPENDICULAR
TO THE PLANE OF THE CUBE APICES

FIG. IOA

PROJECTION ALONG
CUBE DIAGONAL

FIG. IO
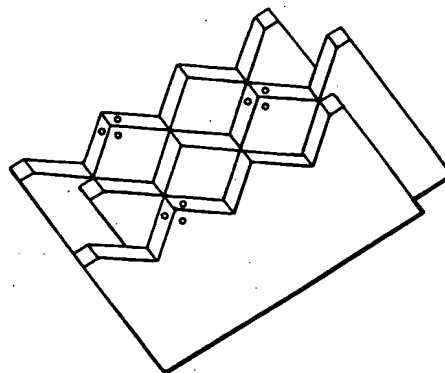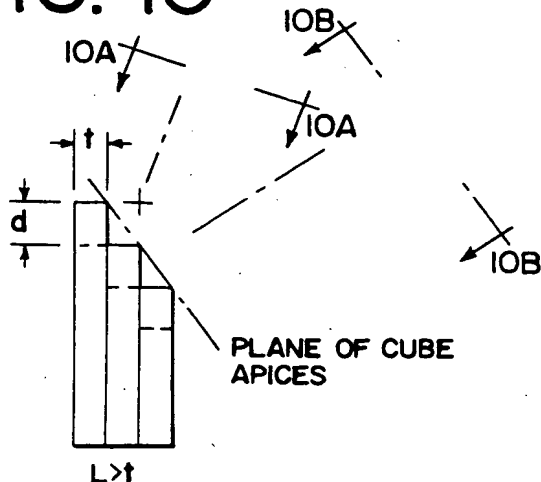
FIG. IOC

PROJECTION PERPENDICULAR
TO FACE OF PLATE

PLANE OF CUBE
APICES

L>t

FIG. 11A

CUBE EDGE

CUBE FACE

CREST OF
GROOVE 20

b

ROOT OF
GROOVE 21

11B

FIG. 11B

CUBE EDGE

CUBE FACE 19

17   18
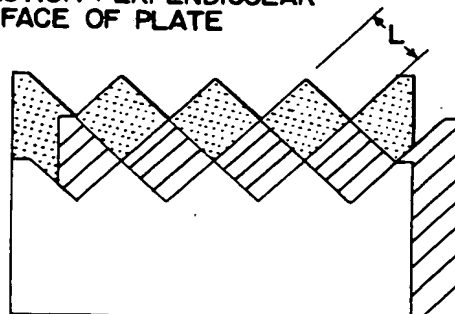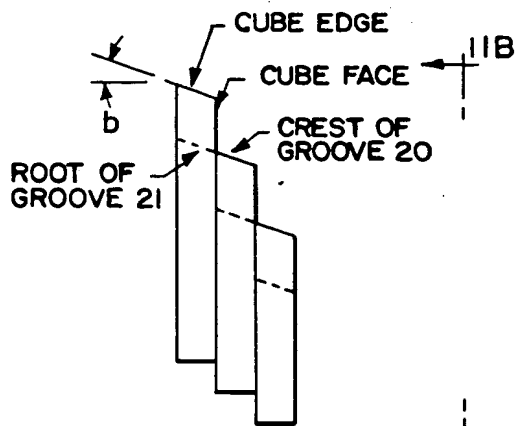
11B
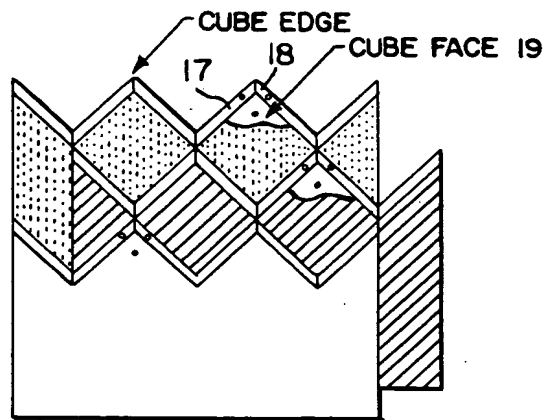
FIG. 11

PLATE ANGLE HIGHLY
EXAGGERATED

CREST OF GROOVE

ROOT OF GROOVE AND
DIRECTION OF CUT

b

$90° + b$

12A

28

t

$d = 0.707t$

30

$s = 0.932t$

PLANE OF CUBE
APICES

29

12A
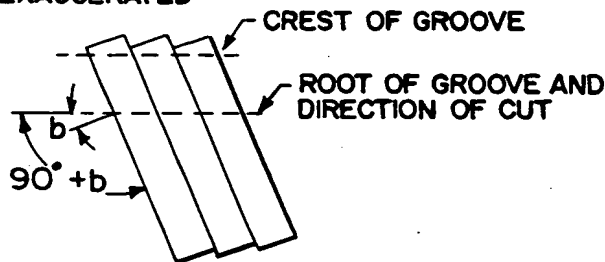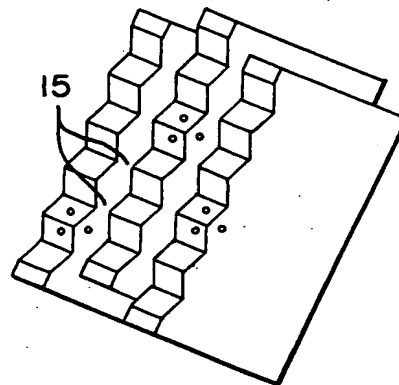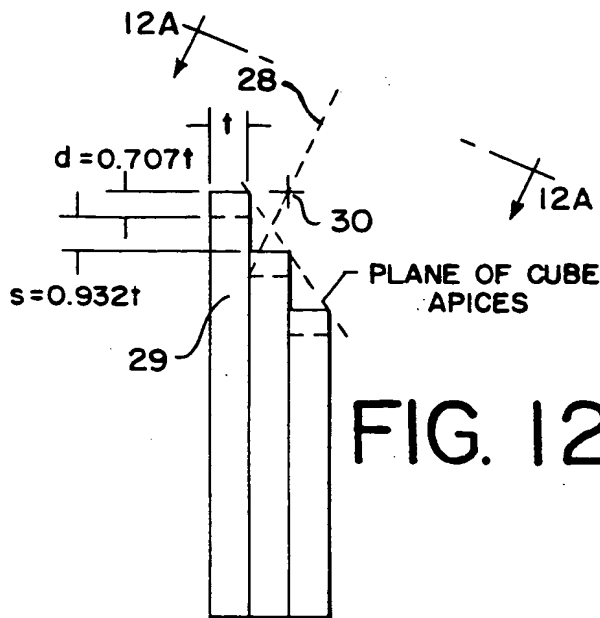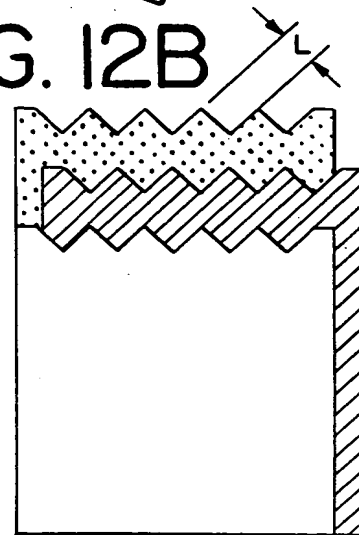
FIG. 12

PLATES DISPLACED SO GROOVE
EDGE DOES NOT MEET GROOVE
ROOT OF ADJACENT PLATE L=t

FIG. 12A

PROJECTION ALONG
CUBE DIAGONAL

15

FIG. 12B

L

PROJECTION PERPENDICULAR
TO FACE PLATE

FIG. 12C

INTERRELATIONSHIP OF
d, s, t, I AND I'
FOR NEGATIVE VALUES OF I
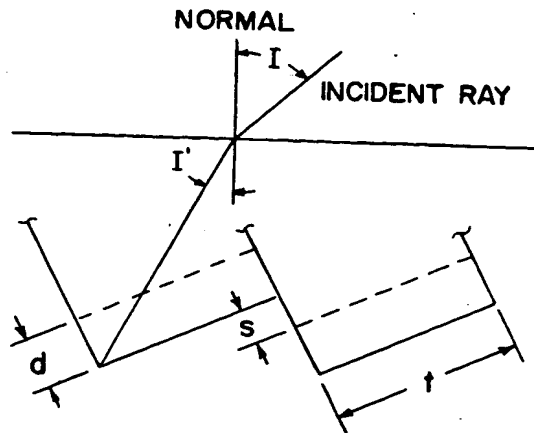
FIG. 12D

INTERRELATIONSHIP OF
d, s, t, I AND I'
FOR POSITIVE VALUES OF I
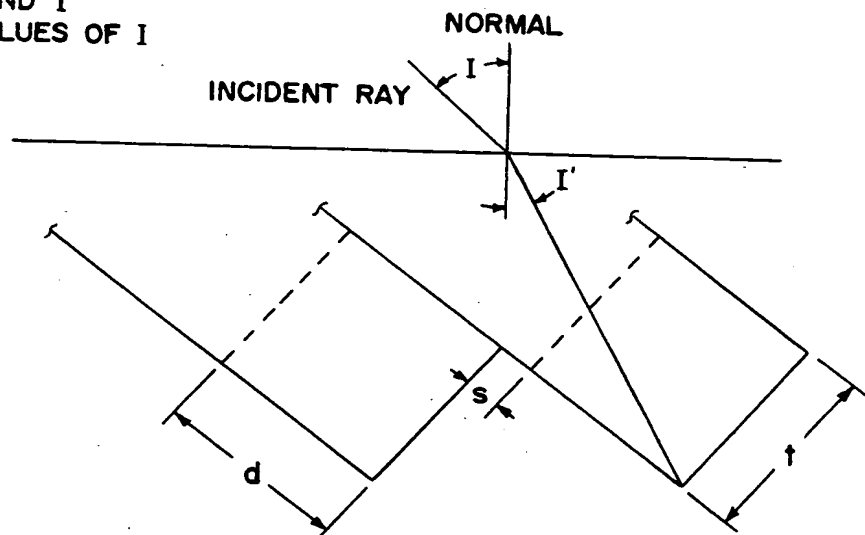
FIG. 13

FIG. 14A   FIG. 14B

t

110

112

FIG. 15

119

CUTTING EDGE PERPENDICULAR
TO MACHINE BED

119A

XY PLANE

112

113

⊗

125   110

124

112

115

X

110

111

FIG. 16A

113

112

110

FIG. 16B

113

112

110

FIG. 17

114   115

PERPENDICULAR
TO MACHINE BED

x

110   111   110   111

18   18

FIG. 18

118

114

116A

19

116   Y

110

116

19

FIG. 21

110
110
110

FIG. 20

110

100B

100C

100A

100

116

100   113

FIG. 19

20

20   113

116

110
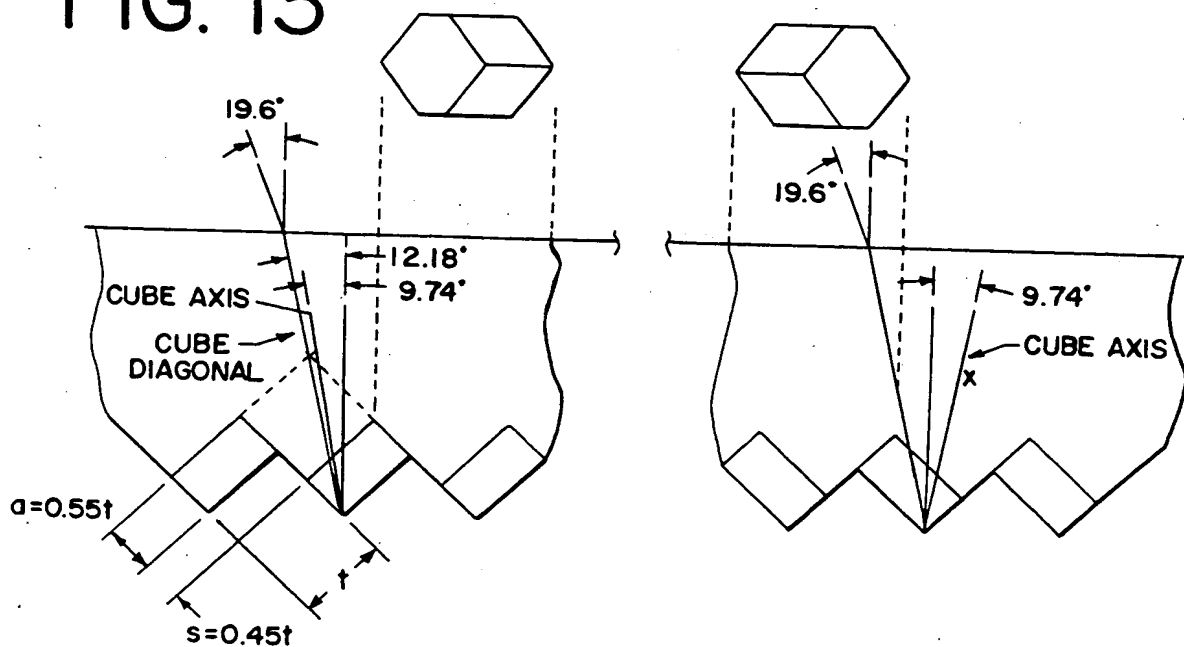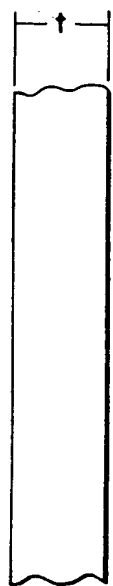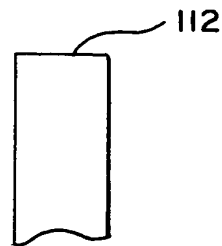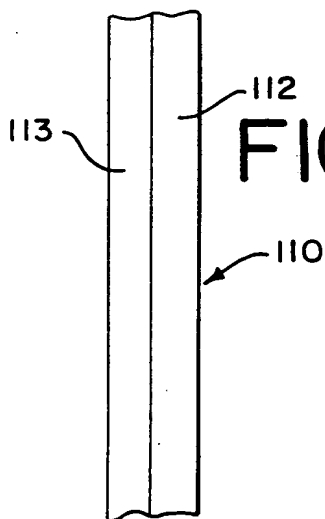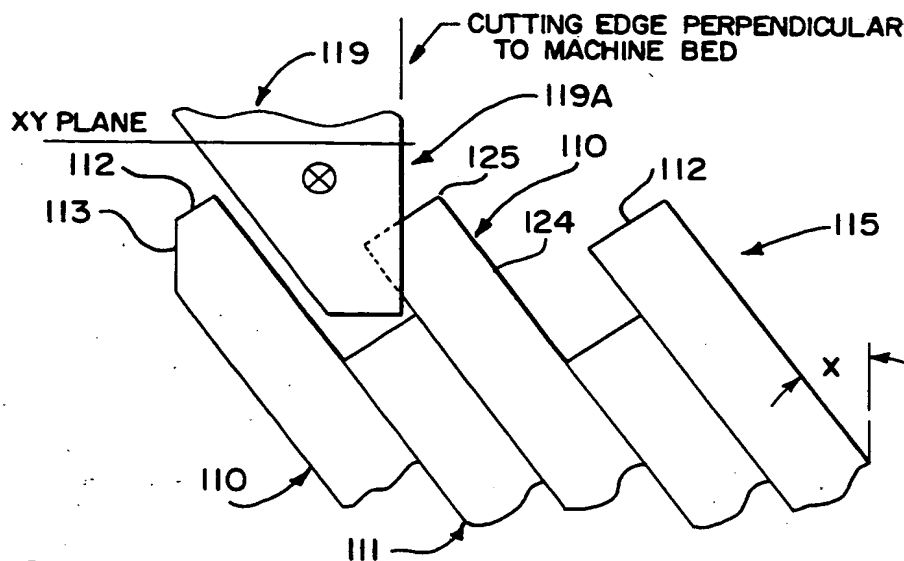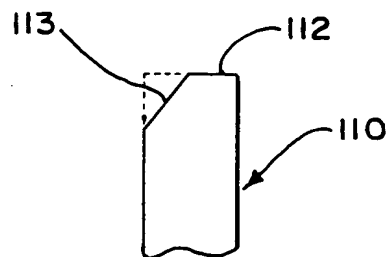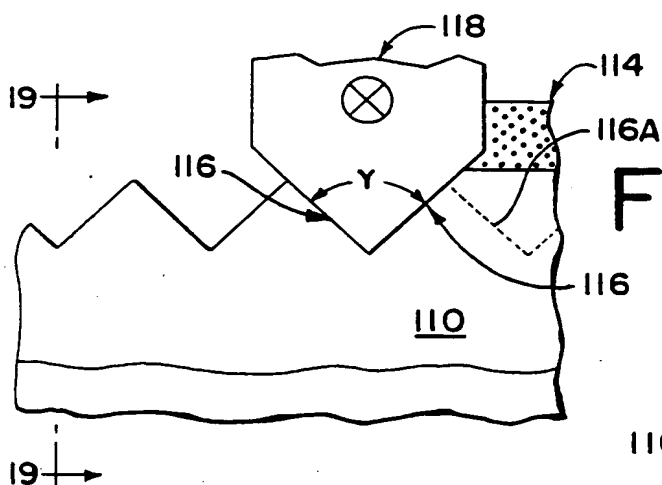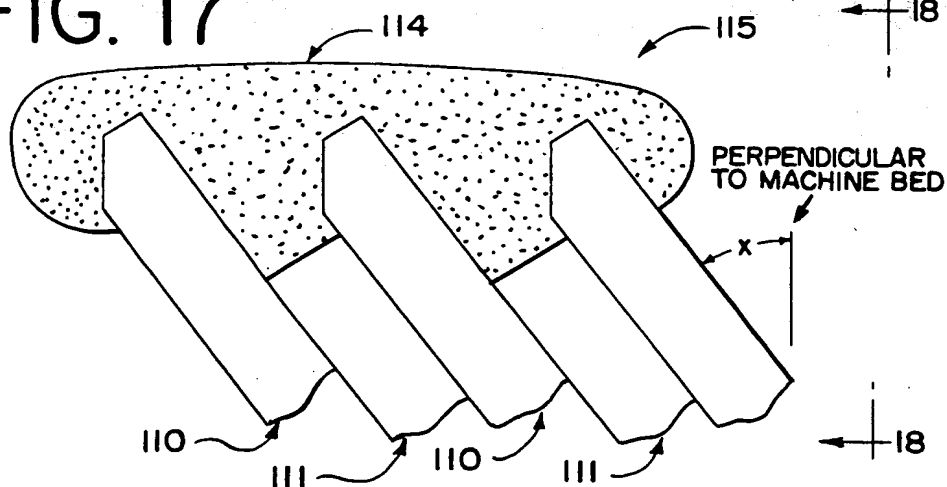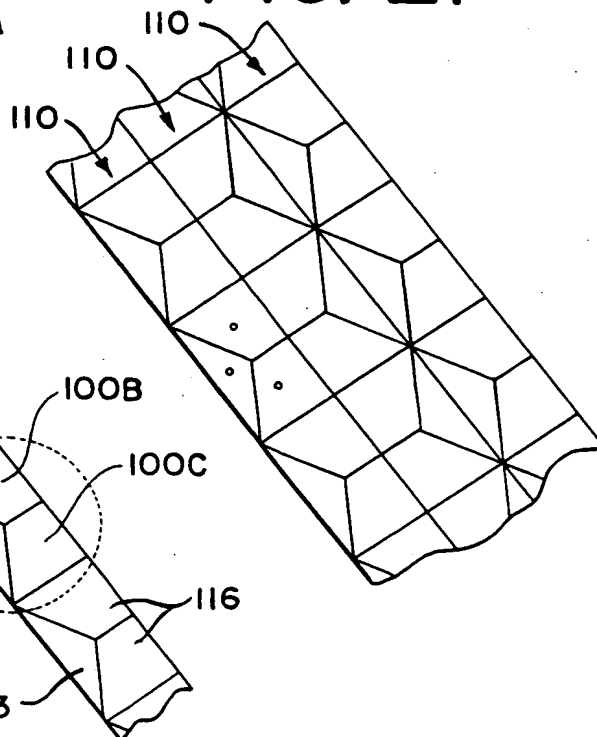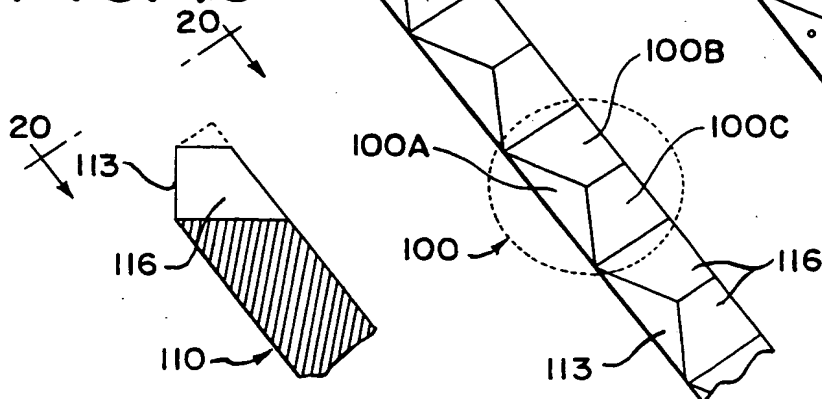
FIG. 22A

TOOL CUTTING EDGE PERPENDICULAR TO MACHINE BED

219

⊗
Z

X < Z < 2X

219B 219A

FIG. 22B

213A

213

210

FIG. 22C

114

213

213A

210

22B

225

224

222

PERPENDICULAR TO MACHINE BED

X

22B

212

210

213

FIG. 22

213A

223

200

200B

200C

200A

216

220

216

213

213A

FIG. 23

118

TOOL FOR FACES 216

⊗

114

220

216

Y

23A

216

223

221

216

210

FIG. 23B

23B

213

216

X

23B

213A

223

221

FIG. 23A

210

FIG. 25B

300B
300
300C
300A
320
316
313
316
220
216
213
216

25B

320
316
25B
313
321
223
220
210
221

FIG. 25A

CUTTING EDGE PERPENDICULAR
TO MACHINE BED

⊗ 219

313
212
213A
213
224
216

X

PERPENDICULAR
TO MACHINE BED

FIG. 24

FIG. 25

118
114
⊗
Y
316
320
25A
223
221
316
220
25A

FIG. 26

H = W

400C

400A

400B

FIG. 27B

500B
500
500C
515
515
516
513
516
515
420
500A
416
413
416

27B

FIG. 27

118
114
516
Y
521
27A
420
423
421
27A

FIG. 27A

516
521
513
420
27B
413
416
421
423
210

FIG. 27C

H = 2W
W

19.6°   19.6°

9.74°   9.74°

CUBE AXIS   CUBE AXIS

FIG. 28

APEX
DECENTRATION
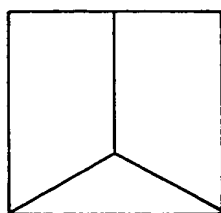
TOWARDS FACE,
58% ACTIVE
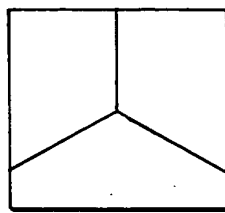
CENTERED,
100% ACTIVE
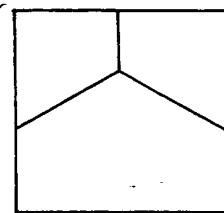
TOWARD EDGE,
58% ACTIVE

BOUNDARY
PROPORTIONS
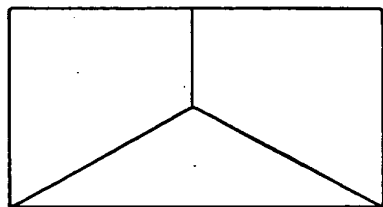
1.73:1
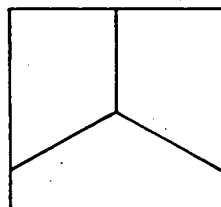
SQUARE
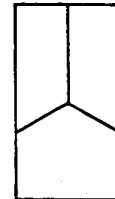
1:2

AXIS
CANT
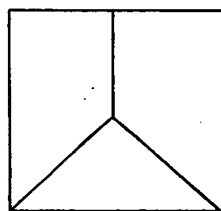
CANT = -9.74°
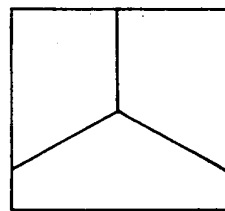
UNCANTED

CANT = + 15°

FIG. 29A

113

PRINCIPAL
REFRACTED
RAY

H

W

116

FIG. 29

θ

X   35.26°

CUBE
AXIS

CAC

0.5W

OPTICAL AXIS

FRONT
SURFACE
TILT, T

FIG. 30

FIG. 31

124

110

X

X

PERPENDICULAR TO
CUTTING PLANE

FIG. 32

FIG. 33

CUT 1   CUT 2

CUT 3

FIG. 34A

CUT 1   CUT 3

CUT 2
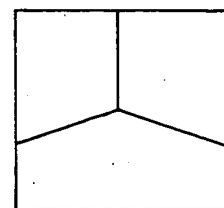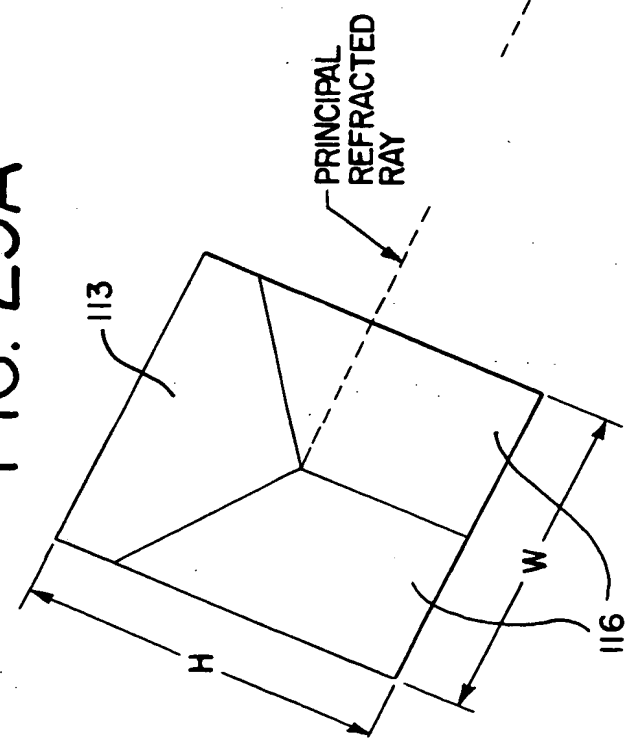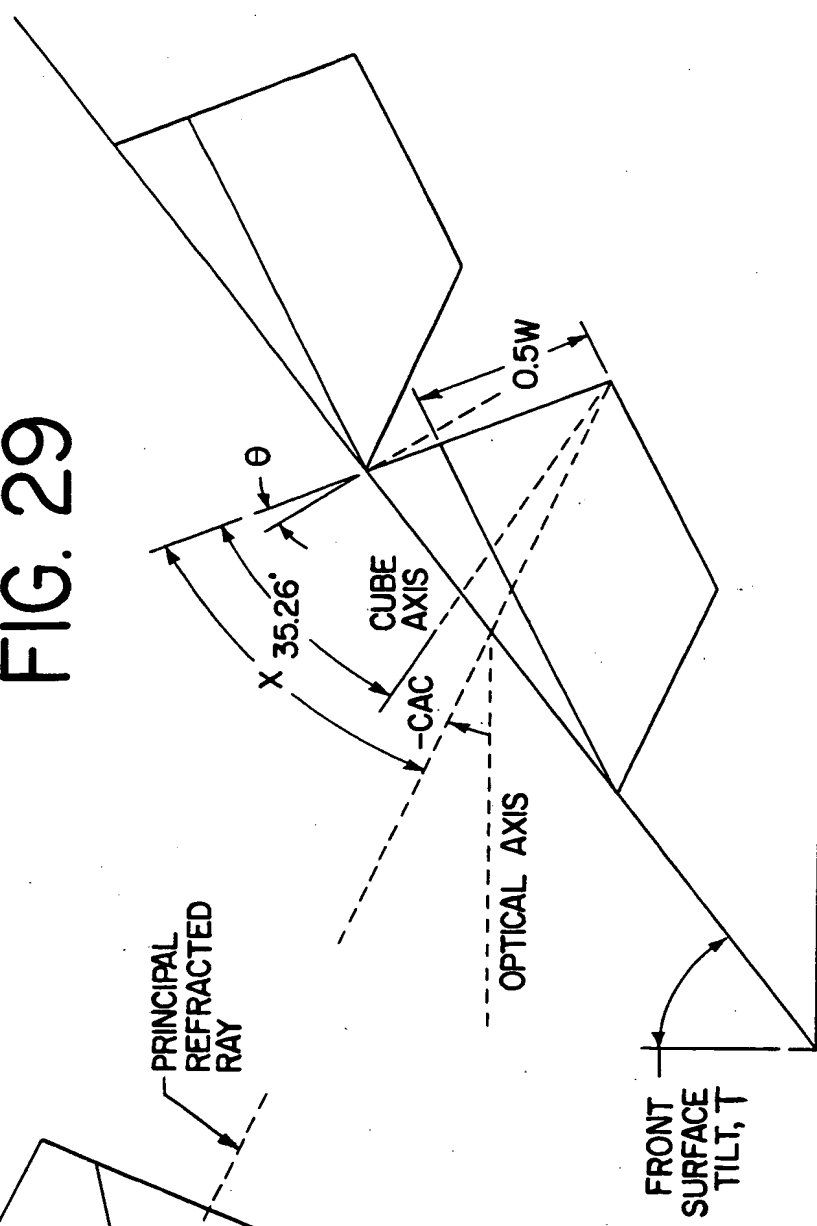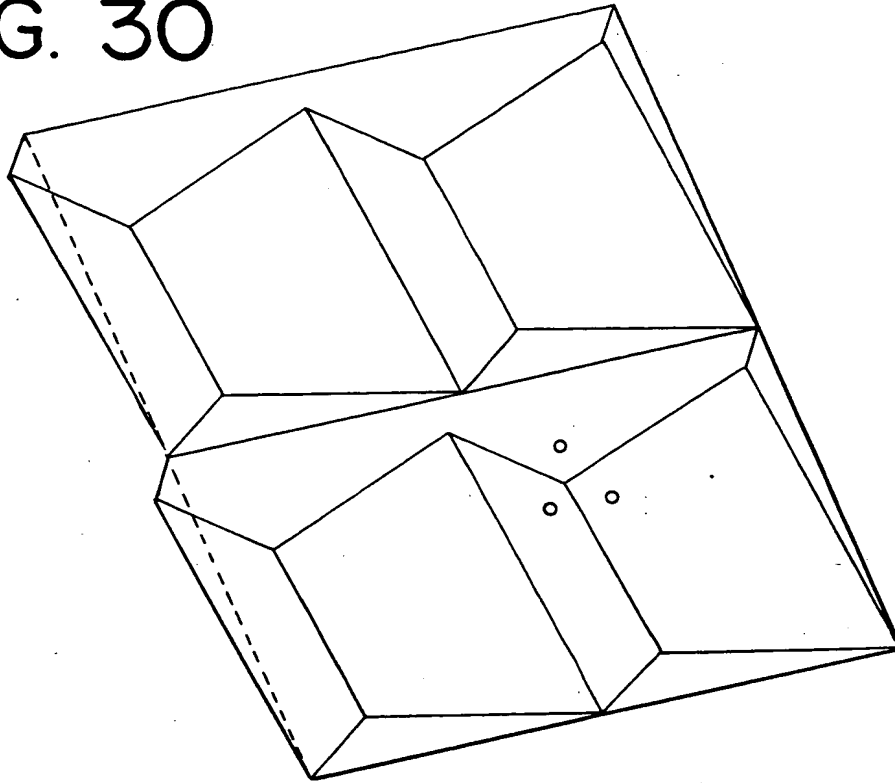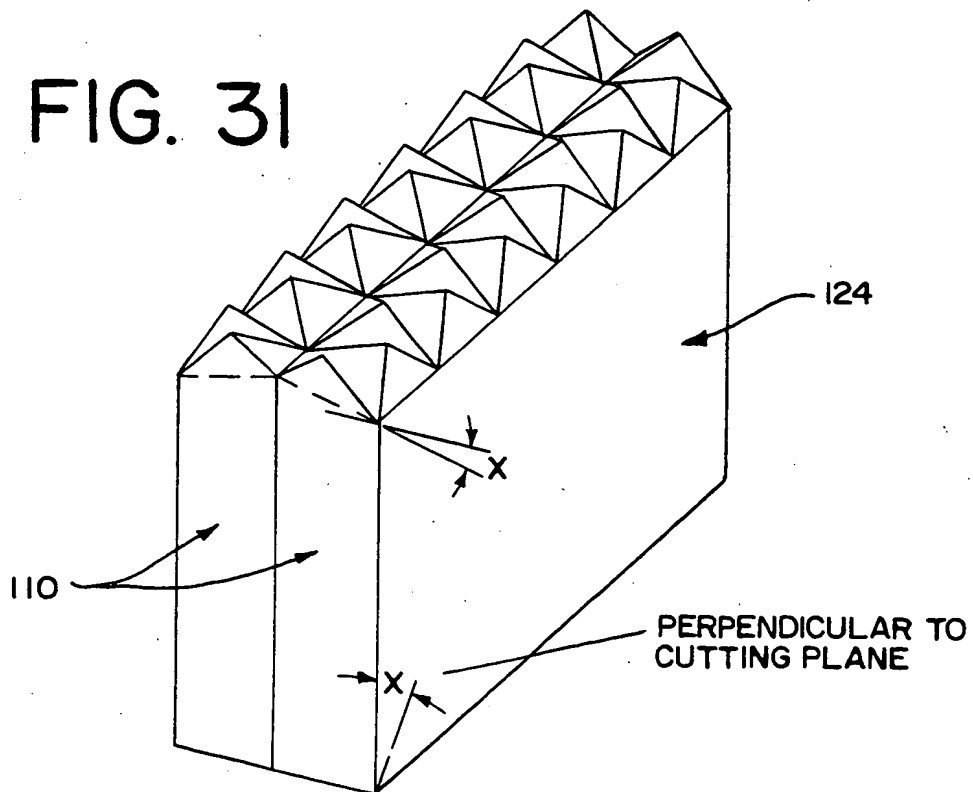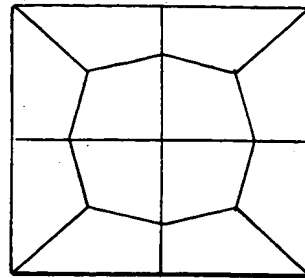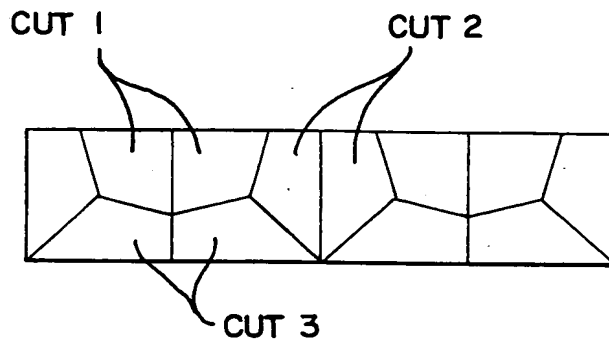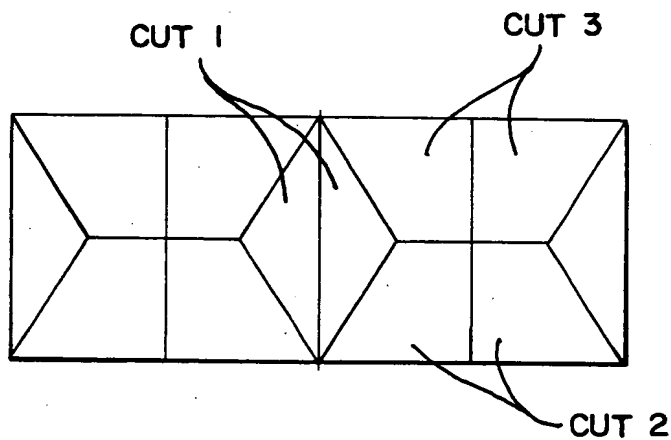
FIG. 34B
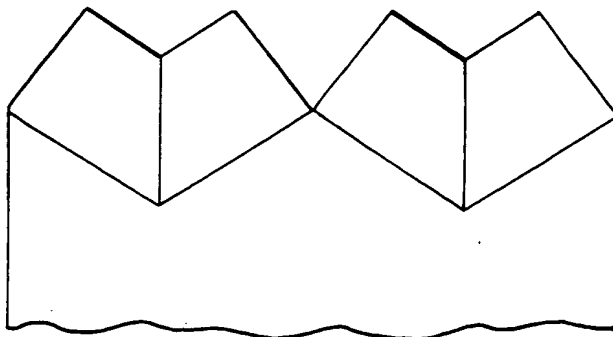
FIG. 35
ARRAY OF PENTA-FACE HEXAGONAL CUBES SHOWING A PLATE HIGHLIGHTED

C

FACES B2

FACES A   FACES BI
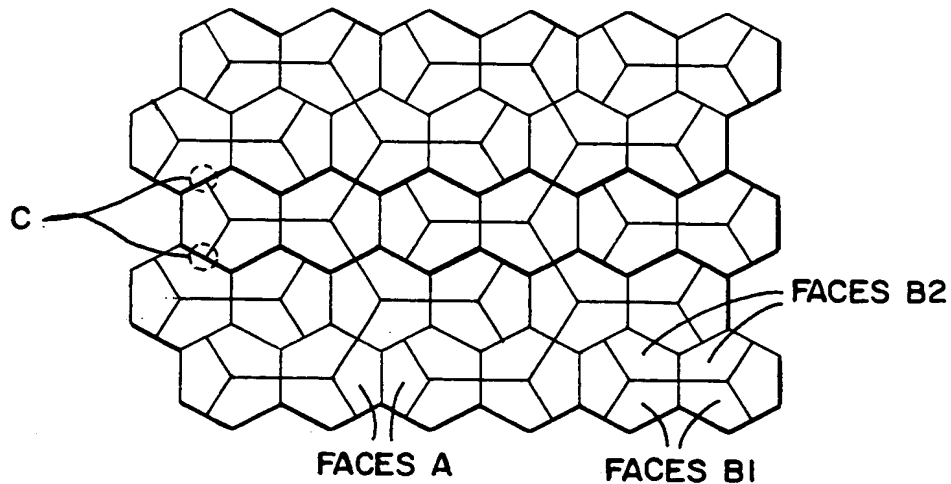
FIG. 36

ARRAY OF PENTAGONAL CUBES WITH
+8.7 AXIS TILT AND 89.8 AREA EFFICIENCY

815

810
813
710
713
710
813
810

715

816   716

FIG. 36A

CANT "v"

g

CANT "u"
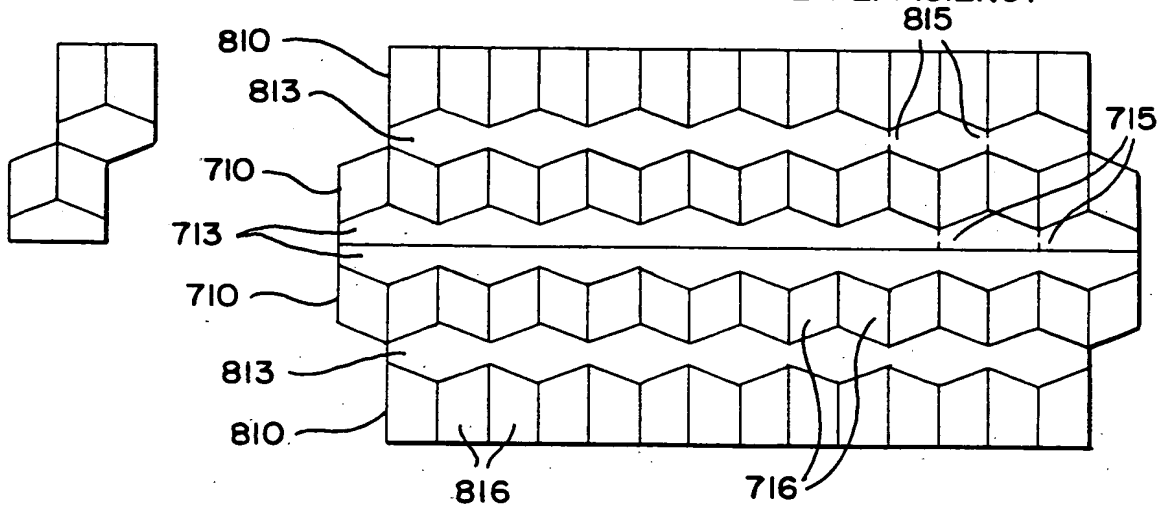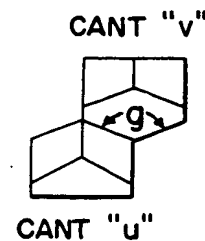
$$g = 2\arctan \frac{\sqrt{3}\cos(v-u)}{\cos(v) - \sqrt{2}\sin(v)}$$

FIG. 37

PERFORMANCE OF SIMPLEST HEXBLADE ARRAY (d/t=.7071, s/t=0, NOT PAIRED)
FORMED IN MATERIALS OF DIFFERENT REFRACTIVE INDICES
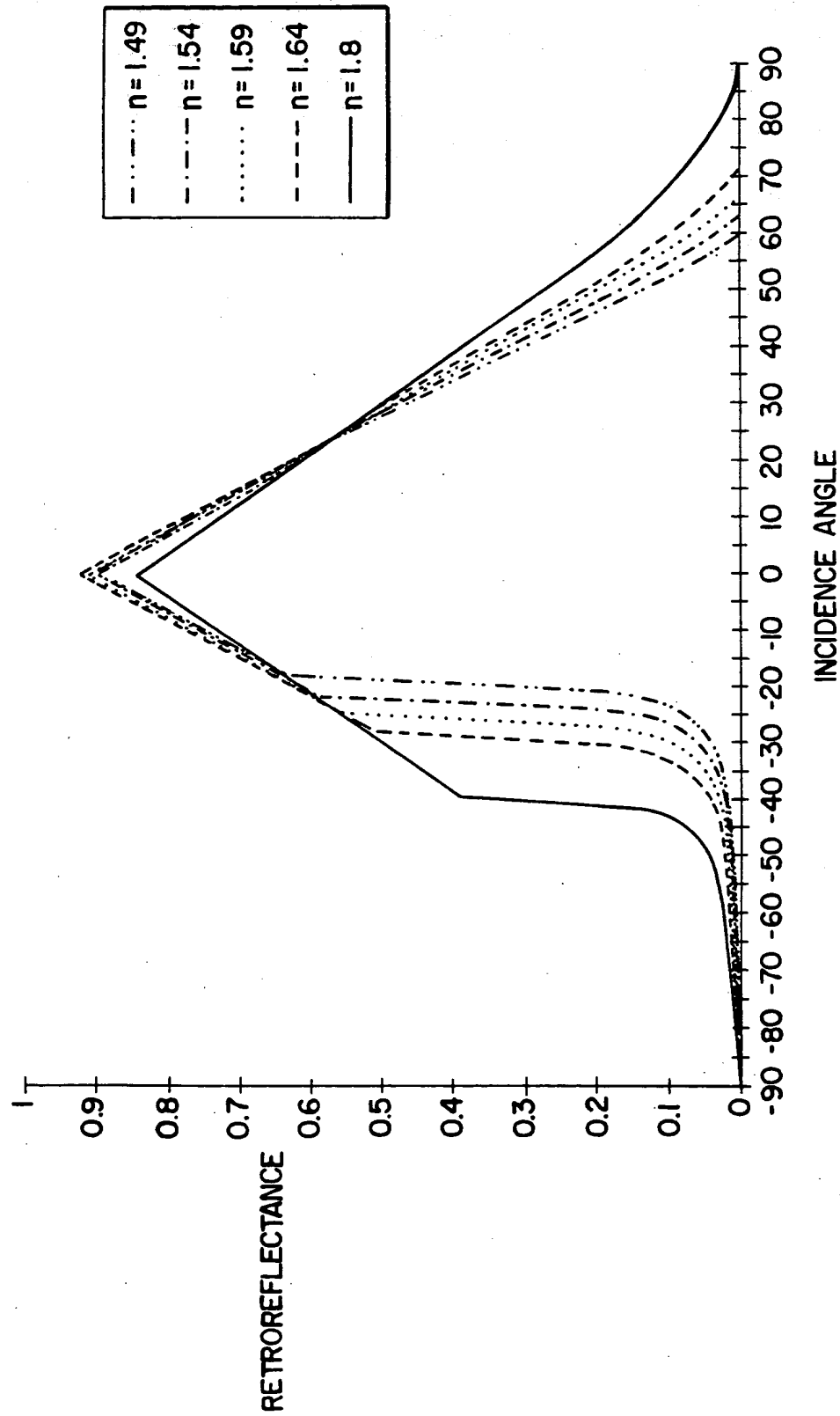
— · · · —	n=1.49
— · — ·	n=1.54
· · · · · ·	n=1.59
— — —	n=1.64
————	n=1.8

RETROREFLECTANCE

INCIDENCE ANGLE

FIG. 38

PERFORMANCE OF HEXBLADE ARRAYS (n=1.49, s/t=0, NOT PAIRED)
OPTIMIZED FOR DIFFERENT INCIDENCE ANGLES

FROM LEFT TO RIGHT

——— d/t=.3071 FOR -80°
——— d/t=.3514 FOR -60°
——— d/t=.4342 FOR -40°
——— d/t=.5520 FOR -20°
——— d/t=.7071 FOR 0°
——— d/t=.9058 FOR +20°
——— d/t=1.151 FOR +40°
——— d/t=1.423 FOR +60°
——— d/t=1.628 FOR +80°

RETROREFLECTANCE

EXTERNAL INCIDENCE ANGLE I

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90

FIG. 39

PERFORMANCE OF HEXBLADE ARRAYS (n=1.49, s/t=0, NOT PAIRED)
OPTIMIZED FOR DIFFERENT INCIDENCE ANGLES

FROM LEFT TO RIGHT

— d/t=.3071 FOR -80°
— d/t=.3514 FOR -60°
— d/t=.4342 FOR -40°
— d/t=.5520 FOR -20°
— d/t=.7071 FOR 0°
— d/t=.9058 FOR +20°
— d/t=1.151 FOR +40°
— d/t=1.423 FOR +60°
— d/t=1.628 FOR +80°

PERCENT ACTIVE
APERTURE

I
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90

EXTERNAL INCIDENCE ANGLE I
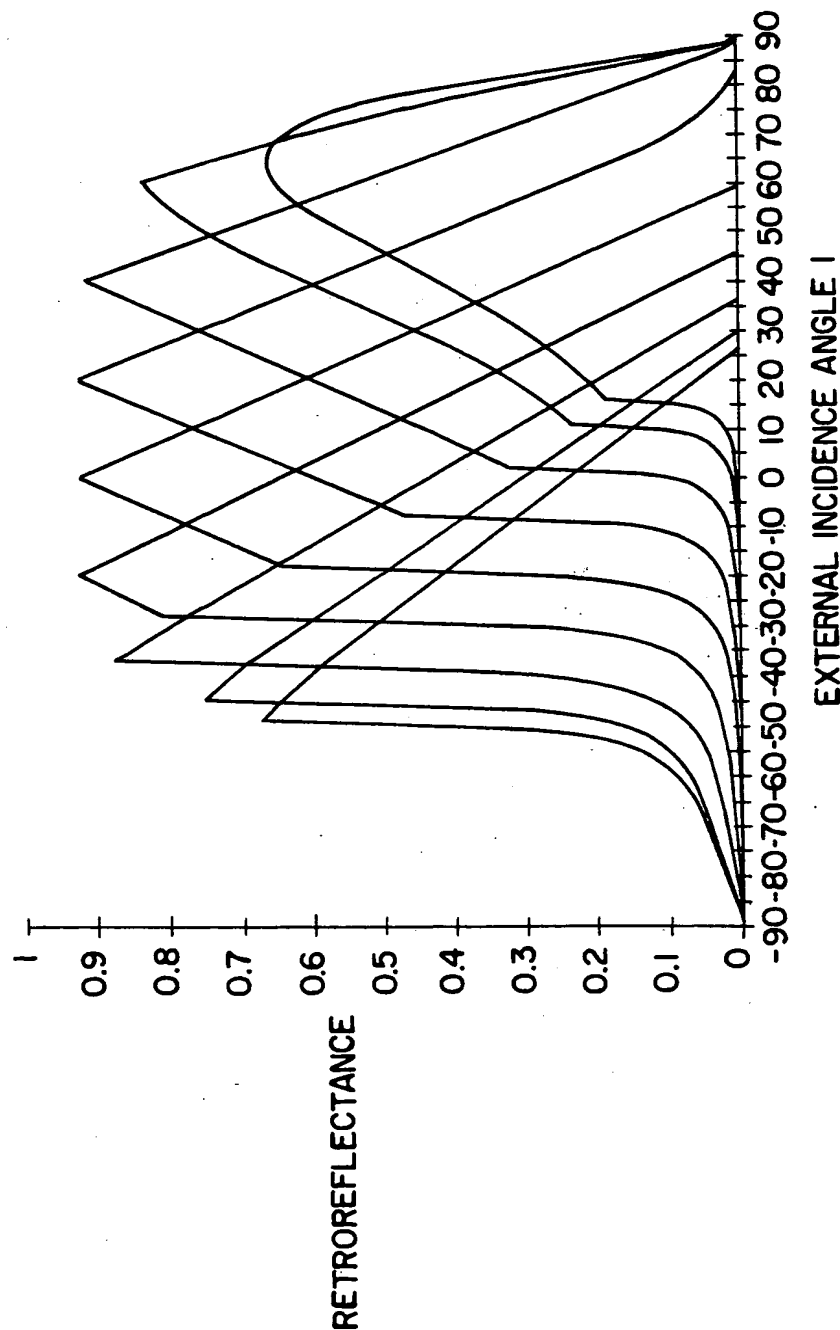
FIG. 40   RECTANGLE AND HEXAGON MICROCUBES OF EXAMPLE I (REFRACTIVE INDEX = 1.59)

FIG. 41

PERFORMANCE OF RECTANGLE CUBES (n=1.49) IN A RAISED PAVEMENT MARKER (FRONT FACE 55 DEG. TO VERTICAL)

CUBE AXIS CANT
.... +1.9DEG
——— -4.0DEG
– – – -9.0DEG

PRIOR ART

RETROREFLECTANCE

HORIZONTAL ENTRANCE ANGLE
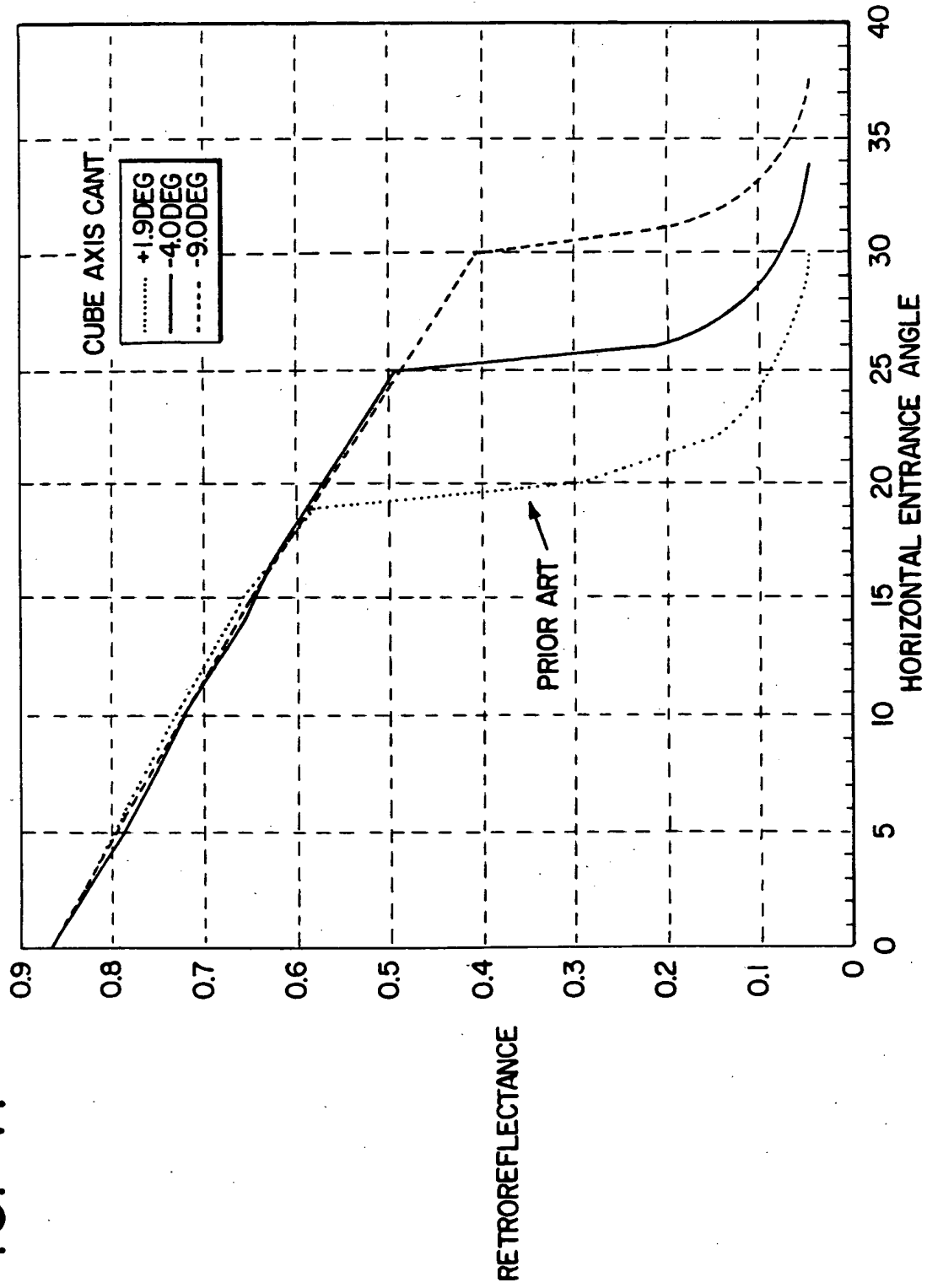
FIG. 42A

RETROREFLECTANCE VERSUS ENTRANCE
ANGLE FOR PAIRED ARRAYS O

d+s=.5t
AXIS TILT = +8.70° EMP

—— d=.lt; s=.4t
---- d=.3t; s=.2t
······· d=.5t; s=0t
—— HOOPMAN

RETROREFLECTANCE

0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
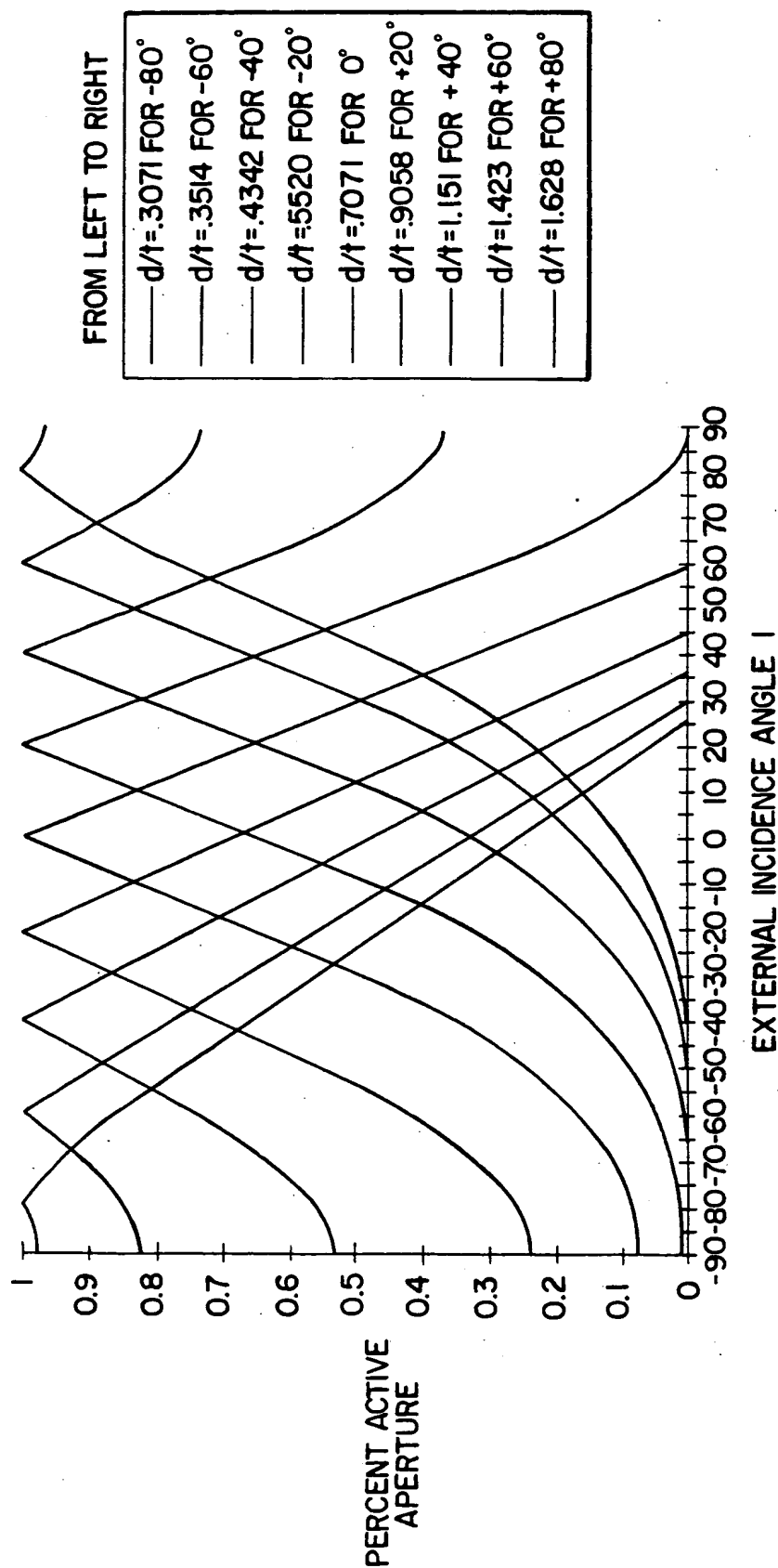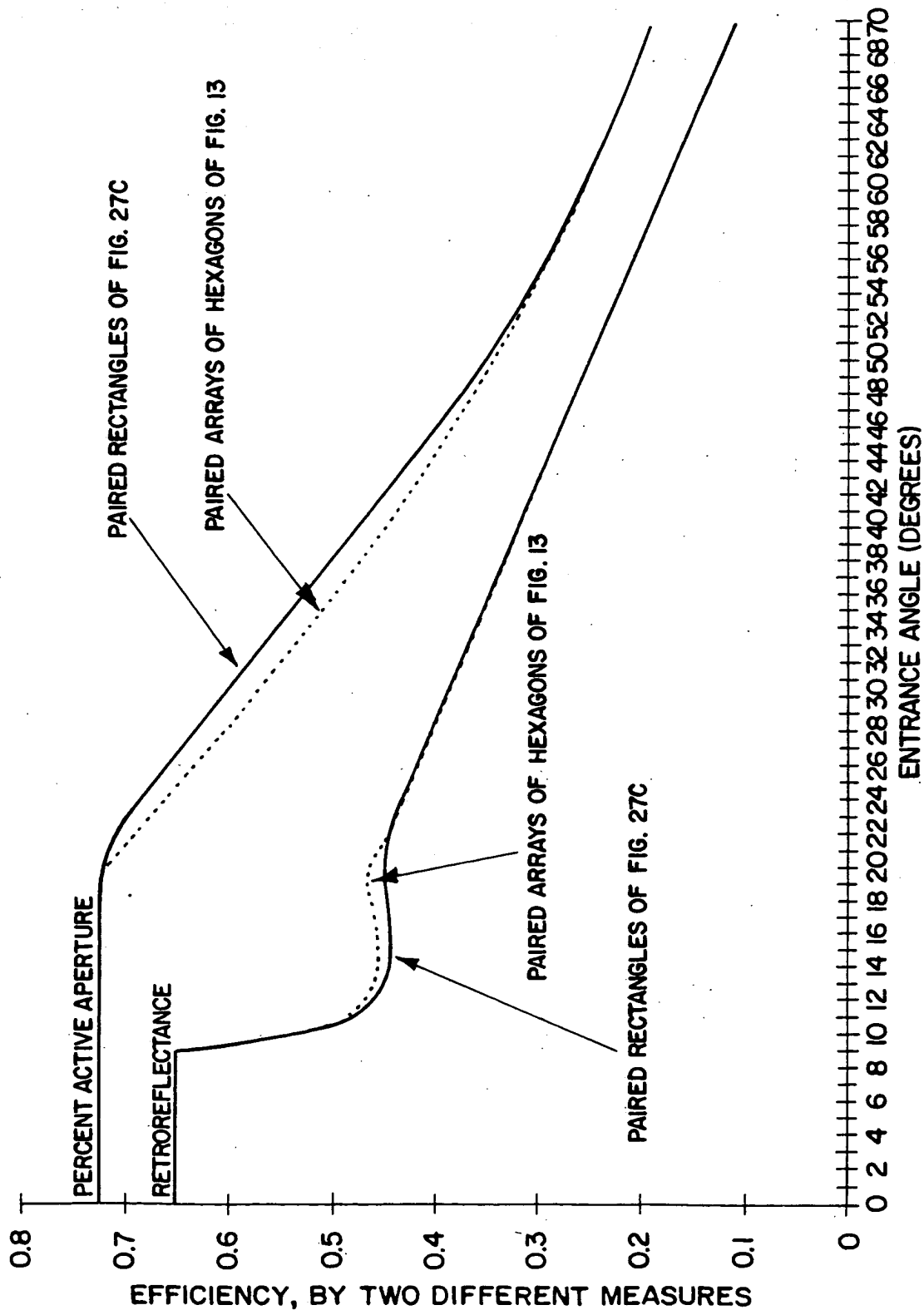
ENTRANCE ANGLE (DEGREES)
0 10 20 30 40 50 60 70

FIG. 42B

d+s=.6t
AXIS TILT = +4.30° EMP

—— d=.lt; s=.5d
---- d=.35t; s=.25t
······· d=.6t; s=0t
—— HOOPMAN

RETROREFLECTANCE

0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

ENTRANCE ANGLE (DEGREES)
0 10 20 30 40 50 60 70

FIG. 42D

$d+s = 1t$
AXIS TILT=-9.74 FMP

— $d=.1t; s=.9t$
---- $d=.55t; s=.45t$
······ $d=1t; s=0t$
—— HOOPMAN

FIG. 42C

$d+s = .707t$
AXIS TILT =0

— $d=.1t; s=.607t$
---- $d=.404t; s=.304t$
······ $d=.707t; s=0t$
—— HOOPMAN

FIG. 42E

RETROREFLECTANCE

d+s= 1.2t
AXIS TILT= -14.93° FMP
—— d=.1t; s=1.1t
----- d=.65t; s=.55t
········· d=1.2t; s=0t
—— HOOPMAN

ENTRANCE ANGLE (DEGREES)

FIG. 43

RETROREFLECTANCE

ENTRANCE ANGLE (DEGREES)
ORIENTED PERPENDICULAR TO SYMMETRY PLANE OF CUBES

PAIRED HEXAGON ARRAYS (d=.55t; s=.45t) OF FIG. 13

PAIRED RECTANGLE CUBES OF FIG. 27C

HOOPMAN

FIG. 44

UNCANTED 1:2 RECTANGLES

UNCANTED SQUARES

153
[WO 95/11470]

155
[WO 95/11470]

159
[WO 95/11470]

151
[WO 95/11470]

% ACTIVE
APERTURE

ENTRANCE ANGLE

FIG. 45

-9.74° CANTED PAIRED RECTANGLES OF FIG. 27C

PAIRED HEXAGON ARRAYS, d=.35†, s=.75†, -12.46° CANT

460 [OF WO 95/11463]

461 [OF WO 95/11463]

% ACTIVE APERTURE

ENTRANCE ANGLE

FIG.46a FIG.46b FIG.46c